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ABSTRACT

A study was done to foster interest in Supplemental Instruction (SI), an instructional intervention which helps students develop study skills relevant to a particular course, and to investigate the effects of participation in an SI program for a first semester, college level mathematics course in business calculus. The course had a consistent grade distribution pattern in which at least 30 percent of the students received a grade of D or F or withdrew. The study used two lecture classes with the same instructor. Each class was divided into two discussion sections, and of those, one from each received the SI treatment. The preliminary group of subjects consisted of 84 students from the control discussion sections and 83 students from the treatment discussion sections. In the control sections the teaching assistant performed typical duties. In the SI sections the assistant performed the same duties but in addition she provided instruction on the study skills relevant to the course as it progressed. The results showed a statistically significant difference between the control group mean semester grade point average (GPA) of 2.51 and that for the treatment group GPA of 2.95, a result suggesting that students receiving SI treatment outperformed their control group counterparts. Included are 4 tables, 1 figure and 22 references. (JB)

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EFFECTS OF SUPPLEMENTAL INSTRUCTION ON STUDENT
PERFORMANCE IN A COLLEGE-LEVEL MATHEMATICS COURSE

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In 1986 five national study panels met separately to discuss problem areas in undergraduate education in the United States. The final reports from the Education Commission of the States, the Alliance for Undergraduate Education, the Carnegie Forum on Education and the Economy, the Commission on the Role and Future of State Colleges and Universities, and the National Governors' Association Task Force on College Quality contained a unifying premise: the state of undergraduate education is in a weakened condition and can only be strengthened through innovative instructional programs and concerted public attention.

Such concern for the success of college and university students is not a recent manifestation. It has long been the mission of college learning assistance centers to provide programs directed toward student academic development. Among these many support programs, Supplemental Instruction (SI) has recently attained national prominence. Developed at the University of Missouri-Kansas City (UMKC), SI is designed to assist students in mastering course content, while increasing their competence in study skills relevant to that course as it progresses (Martin, Blanc, & DeBuhr, 1983). Such a program has the potential to have a positive impact on student performance in college-level coursework, rates of retention, and

completion of baccalaureate degree requirements. This paper documents selected results from a research study designed to foster interest in Supplemental Instruction as well as to investigate the effects of participation in an SI program.

Framework for the Study

As an academic support program, Supplemental Instruction (SI) was developed during a time of transition for college learning assistance centers. During the early 1970's the availability of federal grant monies encouraged the growth of these centers, whose mission was to serve the academic needs of all students (Christ, 1971; Enright & Kerstiens, 1980; Maxwell, 1979; Sullivan, 1980). With the advent of the 1980's, learning assistance centers experienced difficult financial times, as federal grants became increasingly unavailable (Boylan, 1982). In an attempt to maintain existing facilities and to provide the potential for growth, learning center administrators began to work even more closely with their colleagues from academic departments. The programs developed under this partnership reflected a transition from an emphasis on generic learning strategies to an emphasis on strategies specific to courses within an academic discipline. These course-specific learning assistance programs are generally referred to as adjunct courses. (Enright, 1979; Harding, 1981; Hubin & Martin, 1978). The prototypical model for the adjunct course emerged from a program developed by Martin (1977, 1980), which she called Supplemental Instruction.

Martin's Supplemental Instruction model involves the use of subject specialists, called SI leaders, as the facilitators of the program. They are generally upperclass or graduate students who have successfully completed the course to which they have been assigned. The SI leaders have received training from the learning assistance center staff in the study skills necessary for success in the individual academic course. For instance, a training program for chemistry SI leaders would include instruction in problem-solving techniques, while a program for history SI leaders would include a component on taking essay tests. With the cooperation of the individual course instructors, the SI leaders attend lectures, take lecture notes, and complete all assignments. However, their primary responsibility involves conducting the Supplemental Instruction sessions. During these sessions, at which student attendance is voluntary, the SI leaders assume dual roles. As "students of the subject," they use reasoning methods and terminology appropriate to the particular discipline; as learning specialists, the SI leaders are expected to capitalize upon every opportunity to share their knowledge about study skills.

Few experimental studies exist on the effects of student participation in a Supplemental Instruction program. Early reports and monography (Martin et al., 1977; Martin, 1980) detail student achievement levels by using descriptive statistics. Results from another report (Martin & Blanc, 1980) document the first longitudinal investigation on the effects of an SI program. Martin and Blanc found that those students who

participated in SI sessions for an American history course showed patterns of higher course grades and higher rates of retention in college. Results from three case studies (Feyerham, 1983; Whitaker, 1983; Zerger, 1983) and a recent research report (Wolfe, 1987) indicate similar patterns of success in courses such as chemistry, college algebra, economics, and introductory psychology.

Most of the studies mentioned thus far used small sample sizes or did not employ inferential statistics in reporting results. To date, Blanc et al. (1983) have conducted the only large-scale investigation of the effects of participation in a Supplemental Instruction program. Using a sample of more than 700 students enrolled in at least one of four courses, these researchers found that, when compared to classmates who chose not to attend the extra sessions, the SI participants had significantly higher final course grades and semester grade point averages. Furthermore, by tracking these students for an additional two semesters, Blanc and his colleagues found that the SI students had a higher frequency of reenrollment in college than did the non-SI students.

Based on these results, Blanc, DeBuhr, and Martin concluded that Supplemental Instruction is an effective program that can affect a student's achievement level in college courses, rate of retention in college, and ultimately, the likelihood of earning a baccalaureate degree. While these data seem encouraging, some methodological restrictions limit the conclusions as well as the generalizability of the results. For example, the experimental

design failed to account for possible effects from using different courses, course instructors, and SI leaders. More importantly, however, neither this nor any of the previous studies addressed a basic question: Did the differences between the groups truly come from the unique effects of the Supplemental Instruction program, or did the differences merely come through a form of "double exposure" to the course content? In the existing studies, the SI participants were compared to classmates who had not attended any of the extra sessions. Thus, it can be argued that one group was receiving more exposure to course content than the other. This situation clouds interpretation of the beneficial effects of the integrated study skills component, an idea which is central to the SI model.

Experimental Design and Procedures

The present study was undertaken to investigate the claims made by Blanc et al. (1983) concerning the effects of an Supplemental Instruction (SI) program. An additional purpose was to conduct an experiment that would obviate interpretive problems appearing in previous SI studies. The study was conducted at a large research institution of higher education located in the southwestern United States.

A first-semester calculus course for business and economics majors offered through the mathematics department became the context for the experimental Supplemental Instruction program. The course consistently showed a grade distribution pattern in which at least 30% of the students received a grade of D or F,

or withdrew from the course; thus, it could be classified as a "high-risk" course as defined by Blanc et al. (1983).

Additionally, the instructional format of the course was conducive to a Supplemental Instruction program. Each large lecture class was divided into three discussion sections. These smaller sections provided an appropriate SI setting in that the systematic melding of course content and relevant study techniques is meant to occur outside of the main classroom environment; SI activities are designed to be supplemental to and supportive of the instructor's lecture.

The final consideration in choosing the business calculus course was a desire to avoid introducing the confounding factor of multiple academic disciplines. In the Blanc et al. study (1983), the sample was comprised of students enrolled in at least one of four courses -- American history, biology, chemistry, and economics. However, the use of courses from different disciplines may have clouded interpretation of the results. One of SI's basic tenets is that appropriate study techniques are introduced at the most advantageous times within the course structure. Yet, study skills necessary for success in one academic area may differ substantially from those in another (Goldman & Warren, 1973). Therefore, concentration upon a single course afforded the opportunity to analyze more clearly any effects from an SI program.

The experimental design for this study used Campbell and Stanley's Nonequivalent Control Group model (1963) as its theoretical base. The practical aspects of this design necessitated

some important personnel decisions. The first of these involved selecting two intact lecture classes of business calculus, each having the same instructor. This use of a single instructor eliminated one of the recurrent problems in existing SI studies (Blanc et al., 1983; Martin & Blanc, 1980) -- the lack of control for instructor effects.

The second personnel decision involved the teaching assistant (TA). For each lecture section of business calculus, the instructor was assigned a graduate student who served as the TA. This person's primary role involved leading the twice-weekly discussion sections. To provide for her participation in the study, the experimenter was assigned to be the teaching assistant for two discussion sections from each of the large lecture classes. The decision to involve only a single assistant was made in reaction to the Blanc et al. study, which used seven different assistants, but did not account for their potential effects on student achievement.

Figure 1 provides a diagrammatic summary of the experimental situation. The two large lecture sections of business calculus were taught at adjacent time periods; a coin-toss determined which set of two discussion sections would receive the SI treatment. Two discussion sections, one from a morning and one from an afternoon time period, became the SI treatment group. A similar time structure characterized the two control group discussion sections. The remaining two sections were led by another teaching assistant. Neither he nor his students were a part of the experiment.

In the control group discussion sections the experimenter , performed duties which were typical for a teaching assistant -- attending the course lectures, assisting students during office hours, grading tests, and leading the discussion sections. Her responsibilities in the discussion sections involved answering questions from homework assignments, clarifying concepts from lecture material, and conducting test review sessions.

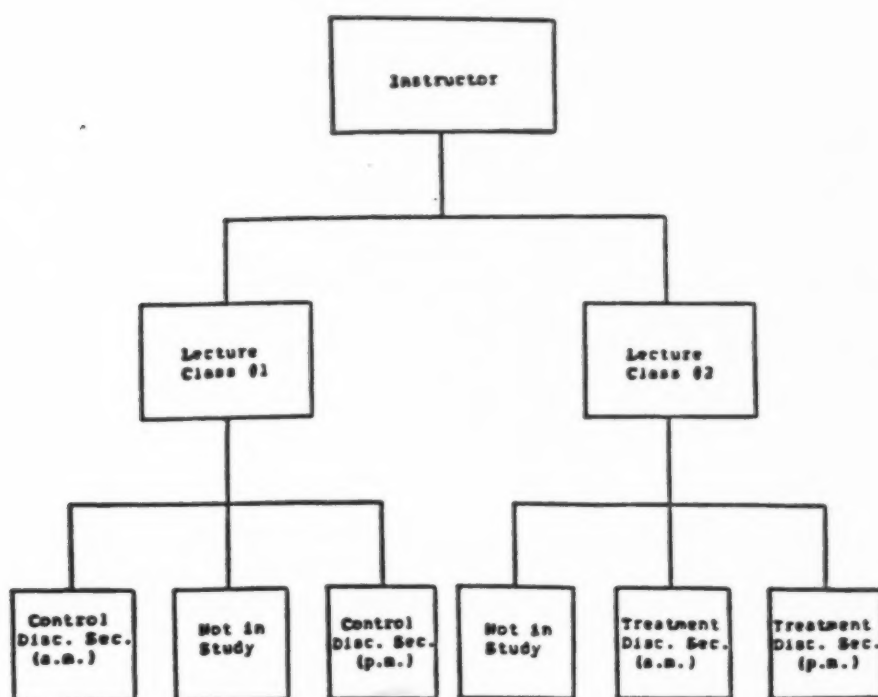


Figure 1

Diagram of the Experimental Situation

The experimenter's role in the treatment group discussion sections involved the same core of activities that she performed in the control group sections. However in addition to dealing with course content matters, she provided instruction on the study skills relevant to the business calculus course as it progressed. Thus, in the treatment group discussion sections, she served as a Supplemental Instruction (SI) leader. The list below details some of the activities devised for the treatment group students:

- practice tests during which the students could work together to solve the problems.
- advice on successful test preparation techniques.
- post-examination surveys in which the students reacted to their performance on the in-class tests.
- instruction sheets on taking effective lecture notes as well as examples of the SI leader's own class notes.

Although the experimenter's presence in both the non-SI control group and the SI treatment group eliminated some potential effects, it created the threat of experimenter bias. If, however, circumstances are such that the experimenter must participate in a study, Rosenthal (1964, 1966) suggested that a possible control would be to conduct periodic observations. This study included a series of in-class observations, using an instrument devised to verify that this experimenter's actions were appropriate for both groups. The observations were conducted by two mathematics educators, each of whom was familiar with college-level instructional techniques and experienced in

classroom observation. After receiving an explanation of the instrument, they participated in practice observations of the control and treatment environments until an 80% level of inter-observer agreement was reached.

Each observer attended four meetings of the control discussion sections and four meetings of the treatment discussion sections. The observations occurred each month so as to document the experimenter's behavior over the course of the entire semester. Results from the observation sequence showed an appropriate difference in her behavior between the control and the treatment sections.¹ Thus, it was determined that she served as an SI leader for the treatment group students and as a teaching assistant for the control group students.

The quality of assistance given by the TA/SI leader arose as another potential threat to the interpretation of results. It was the experimenter's goal to provide an acceptable level of course content support to both the control and treatment group students. An institutionally developed course-instructor survey instrument was used to measure her effectiveness as perceived by students who completed the questionnaire. The instrument was administered two weeks before the semester ended; the experimenter was not present as the students completed the survey. A comparison of the results, reported using a Likert-like scale of 4 (Definitely Yes) to 0 (Definitely No), showed that she received an overall average rating of 3.6 from both groups of students. Thus, it appeared that she exhibited the same high level of assistance in both the control and treatment groups.

Selection of the Sample

The preliminary group of subjects consisted of 84 students from the control discussion sections and 83 students from the treatment discussion sections. To avoid the possibility of bias the experimenter did not review any student's background data until the end of the experiment.

Selection of students to be included in the sample was based on certain criteria. One set of criteria involved the independent variables for data analysis. First, a student's official record had to contain a complete set of standardized test scores as well as an indication of high school class rank. The test scores were from the College Board's SAT and Mathematics, Level I Achievement Test. The latter test was used locally for placement in mathematics courses.

Another requirement was that a student's official college transcript showed no evidence of prior enrollment in a first-semester business calculus course or its equivalent. It was believed that exclusion of these students might lessen the influence of prior subject knowledge, thus allowing effects from the experimental situation to be perceived more clearly.

A third requirement involved a student's level of attendance at the discussion sections. Findings from the Blanc et al. study (1983) were based upon student attendance ranging from 1 to 26 Supplemental Instruction sessions. However, since SI techniques are meant to be introduced at appropriate times during the course sequence, it can be argued that a student should be present at most of the sessions in order to experience

fully any effects of the program. Therefore, in order to be included in the sample, a student had to attend at least 60% of the discussion section meetings.

The second set of inclusion criteria involved the outcome variables to be used for data analysis. The student must have received a final course grade in business calculus, or a grade symbol of Q (withdrawal from this course only) or W (withdrawal from all courses). This requirement eliminated any student who took the course on a pass/fail basis or who was granted additional time in which to finish the course requirements.

Because a substantial portion of the final grade in this course was based upon results from three instructor-made tests, a content validity study of these tests was conducted. The domain of interest for the validation included the topics appropriate to a first-semester business calculus course. A form was devised to assist in matching each test question with its appropriate content topic(s). Nine persons knowledgeable in the field of mathematics served as the expert judges. Results from the matching process showed a 90% rate of agreement among the judges for all of the tests. Therefore, the tests were determined to be content valid.

Characteristics of the Sample

Once the experiment was over, the use of the inclusion criteria led to the selection of the sample for data analysis. A total of 51 students from the control group -- 31 from one discussion section and 20 from the other -- met the criteria,

while the treatment discussion sections provided a total of 50' students -- 33 from one section and 17 from the other section. As a check for a class effect, students in each pair of sections were compared on the following independent variables: College Board SAT Verbal and Mathematical scores, the Mathematics, Level I Achievement Test score, high school class rank, and discussion section attendance. No significant differences at the .05 level emerged from a series of t tests performed on the data from the two control sections. Therefore, it was assumed that no class effect existed, and these two sections were combined to form the control group. A comparison of data from the two treatment sections showed a similar pattern of nonsignificant differences, thus justifying their collapse to form the treatment group.

The next phase of data analysis compared the two groups on the variables of gender, ethnicity, class (e.g., freshman, sophomore, etc.), and college of enrollment. The data which appear in Table 1 show an approximately equal number of males and females with the Anglo ethnicity predominant. Since first-semester business calculus was an entry-level course, the large number of freshmen enrollees was as expected. The last category, college of enrollment, showed no unusual trends; most students were expected to be majoring in liberal arts (the college through which the degree in economics was offered), or to be majoring in business.

Table 1
Gender, Ethnicity, Class, and College of Enrollment
Data for the Control and Treatment Groups

	Control Group (<u>n</u> = 51)	Treatment Group (<u>n</u> = 50)
Gender		
Male	22	27
Female	29	23
Ethnicity		
Anglo	40	43
Black	3	1
Hispanic	4	1
Asian	4	5
Class		
Freshman	42	32
Sophomore	9	18
College of Enrollment		
Business	40	38
Liberal Arts	11	8
Natural Sciences	0	3
Communications	0	1

Table 2 contains summary data for the control and treatment groups on the set of independent variables. In order to check for differences between the groups, a series of t tests was performed. Since no significant differences were found at the .05 level, it was assumed that the two groups were equivalent on all variables tested.

Table 2
Comparison Between the Control and Treatment Groups
on the Set of Independent Variables

Variable		Control Group (<u>n</u> = 51)	Treatment Group (<u>n</u> = 50)
SAT-V	<u>M</u>	454.5	477.2
	<u>SD</u>	80.8	97.3
SAT-M	<u>M</u>	533.3	535.0
	<u>SD</u>	77.5	83.9
MI	<u>M</u>	518.0	524.4
	<u>SD</u>	59.3	76.1
High School Class Rank (%) ^a	<u>M</u>	83.0	81.3
	<u>SD</u>	16.4	17.3
Attendance (%) ^b	<u>M</u>	77.9	83.0
	<u>SD</u>	13.8	13.5

Note. No significant differences were found at the .05 level between the control and treatment groups.

^a High School Class Rank based on percentage standing in class with 99% being the highest.

^b Attendance based on the percentage of classes attended. Sample sizes adjusted to n = 47 and n = 41 due to incomplete attendance data for 13 students who withdrew from the course.

Research Hypotheses and Results

As part of the statistical analysis, two research hypotheses were proposed and tested. The first of these was:

A comparison of average final course grades in a college mathematics course will show no significant difference between students in a non-SI control group and students in an SI treatment group.

This hypothesis was tested on two levels. The first involved the use of a two-sample t test of mean course grades, with letter symbols quantified by the standard conversion of A = 4.0, B = 3.0, ... , F = 0.0. The sample used to test this hypothesis did not include four control group students and nine treatment group students who had withdrawn from the course and received a nonquantifiable grade symbol of Q. When the control group mean ($\bar{M}$ = 2.43, $\bar{SD}$ = 1.30) and the treatment group mean ($\bar{M}$ = 3.00, $\bar{SD}$ = 1.02) were compared, there was a significant difference between mean course grades, $t(86) = -2.28$, $p < .05$. It appears that students who participated in Supplemental Instruction (SI) earned higher grades in the first-semester business calculus course than those students who did not experience SI. These results are consistent with those reported in previous studies (Blanc et al., 1983; Feyerham, 1983; Wolfe, 1987; Zerger, 1983).

However, this type of analysis provided a rather simplistic view of the effects of a Supplemental Instruction program. The statistical methodology revealed the relationship between group membership and course grades, but it failed to account for any possible relationship between the dependent variable and other independent factors such as aptitude, prior mathematics achievement, and attendance level in the discussion section. Thus, an appropriate multiple linear regression model was chosen as an alternative, and perhaps more complete, method of analysis.

The proposed regression model used final course grade as the response variable and SAT Verbal and Mathematical scores, Mathematics, Level I Achievement Test score, high school class

rank, and discussion section attendance as the quantitative independent variables. The model included group membership as an independent dummy variable, with the non-SI control group coded as 0 and the SI treatment group coded as 1. For brevity the variable names are reported as follows:

SAT-V	SAT Verbal score
SAT-M	SAT Mathematical score
MI	Mathematics, Level I Test score
HSR	High school class rank
ATTEND	Discussion section attendance
GROUP	Control/Treatment group membership
FGR	Final course grade in first-semester business calculus

The proposed multiple linear regression model had the form

$$\text{FGR} = \beta_0 + \beta_1 (\text{SAT-V}) + \beta_2 (\text{SAT-M}) + \beta_3 (\text{MI}) + \beta_4 (\text{HSR}) + \beta_5 (\text{ATTEND}) + \beta_6 (\text{GROUP}) + \text{error}$$

This model contained the underlying assumption that the two regression hyperplanes were parallel with different intercepts. In order to test this assumption two additional models were formulated: one which included all of the variable-by-group interactions, and another which assumed that the group coefficient was equal to zero. Each of these models was fitted to the data, and the residual plots were examined. None of the plots showed any evidence of departure from normality or homogeneity of variance. The appropriate generalized F tests supported the assumption of parallel hyperplanes with different intercepts.

Table 3 contains the results from the regression analysis. The F ratio, $F(6,81) = 7.8586$, $p < .001$, showed that the set of six independent variables was contributing significantly to the

Table 3
Multiple Regression Results Using Final Course Grade
as the Response Variable

Model: $FGR = \beta_0 + \beta_1 (SAT-V) + \beta_2 (SAT-M) + \beta_3 (MI) + \beta_4 (HSR) + \beta_5 (ATTEND) + \beta_6 (GROUP) + \text{error}$

Analysis of Variance

Source	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
Regression	6	46.6238	7.7706	7.8586**
Error	81	80.0921	0.9888	
Total	87	126.7159		

$\underline{r}\text{-square} = .368 \quad \underline{r} = .61$

Parameter Estimates

	Coefficient	<u>t</u> -ratio
Constant	-3.452	-2.89
SAT-V	-0.0016	-1.15
SAT-M	0.0048	1.97
MI	0.0018	1.00
HSR	0.0210	3.12**
ATTEND	0.0174	2.05*
GROUP	0.5055	2.26*

*p < .05

**p < .001

prediction of a student's final grade in first-semester business calculus. Furthermore, a series of t tests showed that three of the independent variables had coefficients which were significant at the .05 level -- high school class rank, discussion section attendance, and control/treatment group membership.

The variable of control/treatment group membership was of primary interest to this study. The final course averages of 2.43 for the control group and 3.00 for the treatment group led to the conclusion that students who had experienced Supplemental Instruction (SI) performed at a higher level of achievement in the first-semester business calculus course. This conclusion became even more important in light of the experimental design used in this study, which attempted to ensure that both groups received the same level of course content assistance. Thus, the apparent beneficial effects of participation in an SI program were not clouded by a form of "double exposure" to the course content, a problem which appeared in previous SI research.

Two other variables, high school class rank and discussion section attendance also emerged as significant predictors of final course grade in business calculus. In the case of high school class rank, this variable was viewed as having a plausible relationship with final course grade. Based on secondary school grade point average, class rank is generally recognized as a measure of prior academic achievement. The students in both the control and treatment groups exhibited similar levels of scholastic achievement, as measured by this variable. These levels may have had a relationship to their college coursework,

and in particular to their performance in the first-semester business calculus course.

The other variable which had a significant regression coefficient, attendance level in the discussion sections, must be interpreted with caution. Each of the students included in this phase of data analysis had attended at least 60% of the discussion sections. Thus, these high frequencies could show evidence of a motivation to succeed in the course on the part of both groups of students. For those students in the control group, attending the discussion sections may have reinforced their understanding of course content; students in the treatment group not only received similar reinforcement, but they also experienced the Supplemental Instruction program. In either case the frequency with which the students attended their respective discussion sections was related to course achievement.

These three variables, then, are ones which are appropriate for a model predicting achievement in the first-semester business calculus course. From another viewpoint, however, one set of variables exists whose significance is conspicuously absent. This study was concerned with achievement in a mathematics course, yet neither the SAT Mathematical score nor the Mathematics, Level I Achievement Test score emerged as a significant predictor variable. It was conjectured that perhaps their high correlation, $r = .454$, $p < .05$, moderated each another's influence on the response variable. A series of reduced model regression analyses supported this conjecture. Each of these models retained four independent variables; only one of the two

mathematical variables was included. With the Mathematics, Level I Test omitted from the model the SAT Mathematical variable became a significant predictor, $t(82) = 3.75$, $p < .01$. In a similar manner, the Mathematics, Level I variable attained significance, $t(82) = 2.39$, $p < .01$, when the SAT Mathematical variable was not included. In both cases group membership, high school class rank and discussion section attendance remained significant predictors. Thus, it appeared that each of the two variables concerned with mathematical performance contributed significantly to the prediction of final course grades in first-semester business calculus. However, when they were both in the model, their high collinearity masked this effect.

The second research hypothesis to be investigated was:

A comparison of semester grade point averages will show no significant mean difference between students in a non-SI control group and students in an SI treatment group.

This hypothesis was tested on the same two levels used in the previous research hypothesis. The first level involved a two-sample t test of mean semester grade point average (GPA) for the 47 control group students and the 41 treatment group students who earned quantifiable grades in the first-semester business calculus course.

The results showed a statistically significant difference between the control group mean semester GPA ($M = 2.51$, $SD = 0.88$) and that for the treatment group ($M = 2.95$, $SD = 0.64$), $t(86) = -2.73$, $p < .01$. Once again, it appears that students

who experienced Supplemental Instruction outperformed their control group counterparts, this time in overall achievement. These results support findings from other studies concerning the effects of SI participation on a student's semester success rate (Blanc et al., 1983; Wolfe, 1987; Zerger, 1983). These researchers contend that SI participants are likely to apply the appropriate study techniques to their other college courses, resulting in a higher level of overall performance, and thus, in a higher semester grade point average.

To investigate further the effects of participation in a Supplemental Instruction program on semester grade point average, a multiple regression analysis was performed on the data. The model proposed was similar to the one used to test the previous research hypothesis in that retained the same set of independent variables, but used semester grade point average (SGPA) as the response variable.

The proposed multiple linear regression model had the form

$$\text{SGPA} = \beta_0 + \beta_1 (\text{SAT-V}) + \beta_2 (\text{SAT-M}) + \beta_3 (\text{MI}) + \beta_4 (\text{HSR}) + \beta_5 (\text{ATTEND}) + \beta_6 (\text{GROUP}) + \text{error}$$

This model also contained the assumptions of parallelism and different intercepts. Once again the model was tested against one which contained the variable-by-group interactions and one which assumed the group coefficient to be zero. None of these three models showed evidence of deviation from the assumptions of normality or homogeneity of variance. The appropriate F tests showed that the assumption of parallel hyperplanes with different intercepts was valid.

The results of the regression analysis using the proposed model appear in Table 4. The analysis of variance results showed that the six independent variables accounted for a significant portion of the variance, $F(6,81) = 7.6149$, $p < .001$. A series of t tests showed that three of the independent variables were contributing significantly to the model -- the SAT Mathematical score, discussion section attendance, and group membership.

The significance of its regression coefficient showed that control/treatment group membership seemed to have a relationship to semester grade point average. A comparison of the treatment group mean ($M = 2.95$) and the control group mean ($M = 2.51$) showed that the SI participants had a higher overall level of semester achievement than those who did not experience SI.

Again, however, the other independent variables that had significant regression coefficients should not be ignored. At first glance the relationship between attendance in the business calculus discussion sections and semester grade point average may seem unusual. One possible interpretation as to why these two variables had a significant relationship involved speculation on attendance patterns. Perhaps the high frequency of attendance was replicated in the students' other classes; however, no attendance data for the other classes was available. A tentative conclusion might be that the more the students went to their classes, the higher their overall semester achievement level.

Table 4
Multiple Regression Results Using
Semester Grade Point Average as the Response Variable

Model: $SGPA = \beta_0 + \beta_1(SAT-V) + \beta_2(SAT-M) + \beta_3(MI) + \beta_4(HSR) + \beta_5(ATTEND) + \beta_6(GROUP) + \text{error}$

Analysis of Variance

Source	<u>df</u>	<u>SS</u>	<u>MS</u>	<u>F</u>
Regression	6	20.0256	3.3376	7.6149***
Error	81	35.4995	0.4383	
Total	87	55.5251		

$\bar{r}\text{-square} = .361 \quad \bar{r} = .60$

Parameter Estimates

	Coefficient	<u>t</u> -value
Constant	-1.6259	-2.05
SAT-V	-0.0001	0.19
SAT-M	0.0031	2.86**
MI	0.0006	0.52
HSR	0.0085	1.93
ATTEND	0.0174	3.06**
GROUP	0.3382	2.28*

*p < .05

**p < .01

***p < .001

Despite its high correlation with the Mathematics, Level I Achievement Test, the SAT Mathematical variable emerged as a significant predictor in this model. In the context of the business calculus course, mathematics aptitude was an important component. The question arose as to why this measure had a significant relationship to semester grade point average. A possible answer appeared when the students' official transcripts were examined. Of the 88 students in the sample, 78 were freshmen. In addition to the first-semester business calculus course, these students were concurrently enrolled in other quantitative courses such as accounting and economics. In light of this courseload the relationship between mathematics aptitude and semester grade point average became more logical.

Implications for SI Research and Implementation

This study of the effects of Supplemental Instruction (SI) has supported findings from previous investigations and has suggested some new directions for this academic support program. Results showed that treatment group students, who experienced SI in their discussion sections, received higher course grades in first-semester business calculus; they also earned higher semester grade point averages. Furthermore, this experiment revealed new information in that the presence of the SI program was not solely responsible for a student's course and semester achievement levels. Rather, the program operated in conjunction with factors such as mathematics aptitude, prior academic achievement, and attendance rate.

These results have implications for future Supplemental Instruction research. Certainly more controlled studies of the effects of SI are warranted. This study was the first to ensure that both the control and the treatment groups received exposure to course content outside of the lecture; it was also the first research study to impose a more stringent attendance requirement for inclusion in the sample. However, the 60% attendance level might restrict the generalizability of the results to students who exhibit similar attendance patterns. Future studies might investigate the influence of SI session attendance. Additionally studies should be designed so that data analytic techniques such as multiple linear regression and analysis of variance would be appropriate. In this way other factors relating to student academic performance could emerge as well as any effects from participation in an SI program.

An area which has yet to be researched with any depth is the behavior of the SI leader. These assistants play pivotal roles in any Supplemental Instruction program, yet no studies exist which document and analyze the behaviors of successful SI leaders. Such observational research would provide insight into the qualities which characterize good SI leaders as well as provide guidelines for the training of these special assistants.

In the area of program implementation, this study showed that the discussion section, when it is available, is a logical location for a Supplemental Instruction program. In the existing SI model the extra sessions are scheduled outside of the regular class meetings and at times convenient to most students enrolled

in the courses. This model appears to function well for some courses. However, in colleges and universities the practice of dividing a large lecture class into smaller discussion sections is quite common. The students in these classes, however, have already committed themselves to as many as five hours of class per week -- three hours to attending the lectures and two hours to attending the discussion sections. Asking them to schedule another two or three hours per week for Supplemental Instruction seems unreasonable, when the same information can be dispensed during the discussion section time. The current SI model, which only considers the adjunct times as appropriate for the integrated content/study skills program, should be expanded to include the discussion section.

Adding an SI dimension to the discussion sections would create the need for a different type of training for the persons leading these sections -- the teaching assistants. Much has been written recently on the performance of college and university teaching assistants and on the need for effective training programs (Ard, 1987; Carroll, 1980; Haring, 1985; Rodriguez, 1985; Russo, 1982). Perhaps teaching assistants could be recruited and trained as SI leaders, and their discussion sections denoted as having a Supplemental Instruction component.

This study has shown that participation in a Supplemental Instruction program may have an impact on student achievement in college-level coursework. Other investigations have established a link between SI and retention in college as well as completion of baccalaureate degree requirements. In light of the growing

body of empirical evidence as well as an established theoretical framework for SI, this unique academic support program deserves more attention. Perhaps the establishment of Supplemental Instruction programs can assist in the revitalization of undergraduate education in this country.

Note

¹A copy of the observation instrument and detailed results from the observation sequence can be obtained by writing to the author, Mail Stop 40-P, Educational Testing Service, Princeton, NJ 08541-0001.

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